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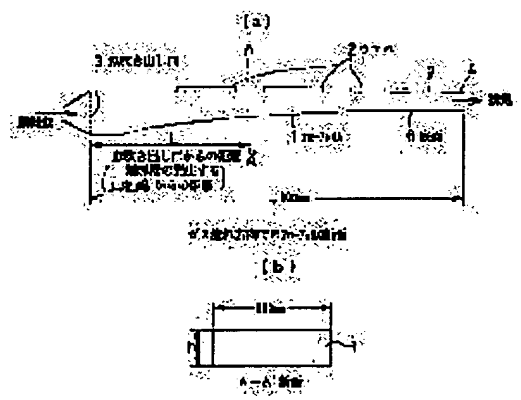
(54) VAPOR GROWTH METHOD AND ITS DEVICE

(57)Abstract:
PURPOSE: To ensure growth of a uniformly thin film without rotating a wafer by keeping the thickness of a boundary layer occurring on a wafer surface constant in a lateral type vapor growth method.
CONSTITUTION: A plurality of holes for a wafer 2 are provided in a flow direction on an upper surface 5 of a flow channel 1 whose cross-section perpendicular to a gas flow is rectangular, these holes set the wafer 2 face down, and a raw material gas in the flow channel 1 is made to flow in parallel to the wafer 2. A bottom 6 of the flow channel 1 is worked in a curve so that a cross-sectional area of the flow channel 1 gradually tapers off toward the flow direction. This enables the product of a distance L from the gas blow-out port 3 multiplied by the cross-sectional area of the flow channel 1 to become constant, thus keeping the thickness of a boundary layer occurring on the wafer surface constant.



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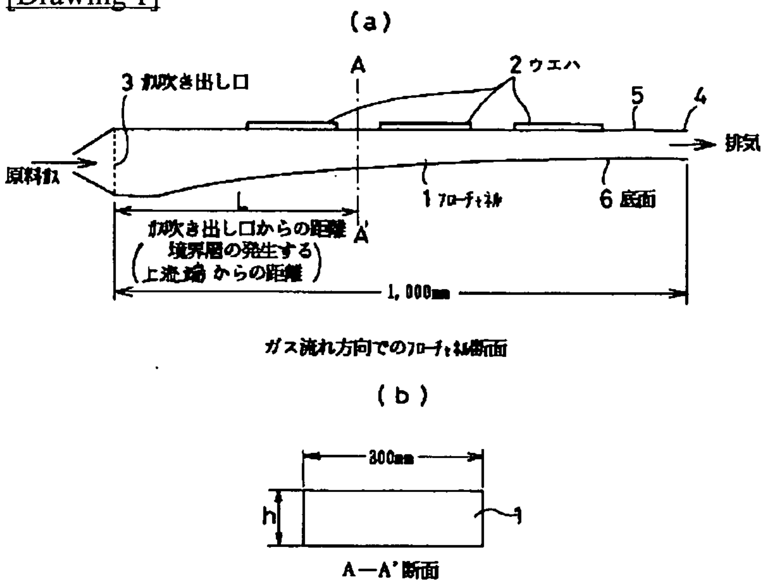
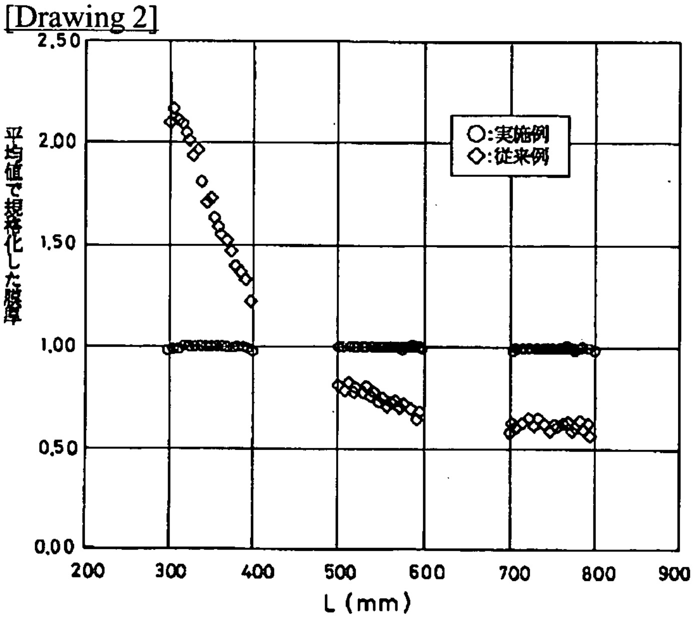
DRAWINGS

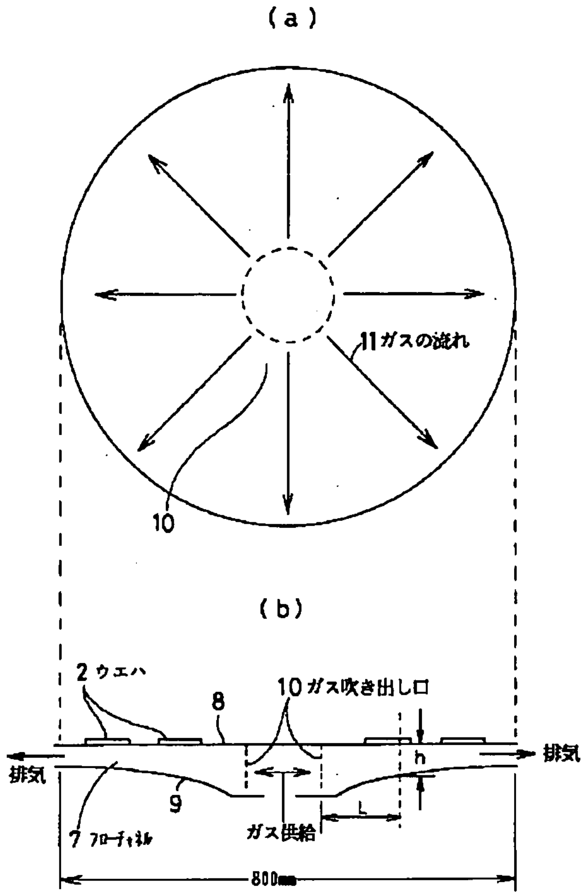
[Drawing 1]



[Drawing 2]

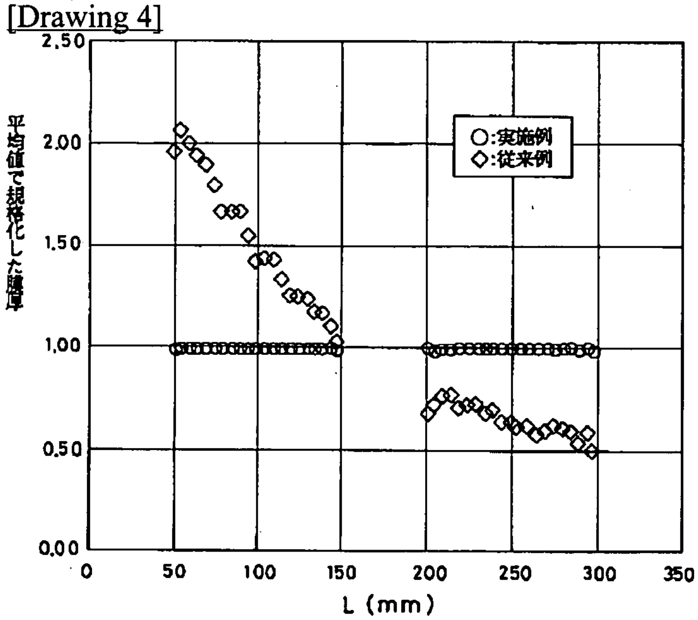


[Drawing 3]



ガス流れ方向でのフローチャネル断面

[Drawing 4]



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the vapor growth approach which kept constant the thickness of the boundary layer which the cross section of a gas flow channel is changed and is formed in a wafer side, and its equipment.
[0002]
[Description of the Prior Art] The almost fixed thing is used until the thickness of the flow channel to which material gas flows a thin film in deposition or the horizontal-type vapor growth equipment which carries out epitaxial growth on a wafer by passing material gas to a wafer and parallel conventionally results [from the upstream of the flow of gas] in the downstream. In this case, by the upstream, the thickness of the film which grows is thick and becomes thin by the downstream. Therefore, in order to obtain the film of uniform thickness, routine of making a wafer rotate within a flow channel conventionally etc. is performed.
[0003]
[Problem(s) to be Solved by the Invention] However, the conventional technique mentioned above had the following faults.
[0004] (1) In order to have to rotate a wafer mechanically, the structure of a growth furnace becomes complicated.
[0005] (2) This control is difficult, although control on the scale of atomic level is being needed especially in the field of semi-conductor manufacture and the thickness control of the very thin film is important recently. That is, the thickness of the film which grew while a wafer did not rotate one time is not uniform in a field. Therefore, in case the very thin film is grown up, a rotational frequency is increased substantially or it is necessary to reduce a growth rate substantially. The former is difficult in respect of a mechanical strength, and, generally the latter has an adverse effect on membraneous quality in many cases.
[0006] The object of this invention is to offer the vapor growth approach that the film of uniform and thin thickness can also grow, without canceling the fault of the conventional technique mentioned above and rotating a wafer. Moreover, the object of this invention has structure in offering easy vapor growth equipment.
[0007]
[Means for Solving the Problem] this invention approach keeps the thickness of a boundary layer constant to a flow direction by passing material gas to a wafer and parallel by seting constant the ratio of the distance from the upper edge where a boundary layer generates a thin film in deposition or the vapor growth approach which carries out epitaxial growth on a wafer, and the rate of flow of gas other than a boundary layer.
[0008] Moreover, this invention equipment equips a wafer and parallel with the flow channel which passes material gas, and makes a thin film in inverse proportion [in deposition or the vapor growth equipment which carries out epitaxial growth / from the upper edge where gas begins to serve as a

laminar flow in the cross section of a flow channel] to distance on a wafer by passing material gas in a flow channel. In this case, while making a cross section vertical to the flow of the material gas of a flow channel into a rectangle, that width of face is set constant and you may make it make the thickness of a flow channel in inverse proportion to distance from the upper edge where gas begins to serve as a laminar flow.

[0009] Moreover, it has the flow channel which this invention equipment has a disc-like growth furnace, and passes material gas from a center to a wafer and parallel toward the method of the outside of the direction of a path, and the square of the distance from the upper edge where gas begins to serve as [thin film] a laminar flow in the thickness of a flow channel in deposition or the vapor growth equipment which carries out epitaxial growth is made in inverse proportion on a wafer by passing material gas in a flow channel.

[0010] Moreover, this invention equipment performs curved-surface processing by straight-line approximation to the top face of the flow channel of the same side as a wafer, or the base of the flow channel of a wafer and an opposite hand in order to make the cross section or thickness of a flow channel in inverse proportion to the square of the distance from the upper edge where gas begins to serve as a laminar flow, or the distance from the upper edge where gas begins to serve as a laminar flow.

[0011]

[Function] In growth of thin films, such as a semi-conductor, it grows up under growth conditions which usually control the thickness of the film which grows by the amount of supply of a raw material chiefly. Under such conditions, when it grows up with vapor growth equipment, the thickness of the boundary layer as used in the field of hydrodynamics is in the big factor which determines distribution of the thickness which grows.

[0012] A boundary layer is a layer to which the rate of flow falls near a wall surface according to the viscosity of gas. In this layer, since the rate of flow is falling, it is thought that a raw material moves mainly by diffusion rather than the flow of gas progresses. In a diffusion phenomenon, the amount which generally moves by diffusion in proportion to the inclination of concentration increases. That is, in growth, the increase of the amount of the raw material which arrives at a wafer front face, and the rate which grows become quick, so that the concentration gradient of the material gas in the boundary layer near the wafer front face is large. Therefore, in order to set thickness of the film which grows constant in a flow direction, the concentration gradient of a boundary layer must be made the same by the upper section and the downstream.

[0013] Concentration of the outside of a boundary layer, i.e., the gas in the part which is fully separated from a wafer, will be made almost equally in a part for an upper part and a downstream, if a raw material is fully supplied. Therefore, the difference of the concentration of the raw material in a wafer front face and a boundary layer outside is uniformly made in the upper section and a downstream. however, time of it being ** by hydrodynamics that the thickness of a boundary layer becomes thick gradually in a flow direction, and the relation setting the rate of flow of gas other than L and a boundary layer to V for the distance from the upper edge where nu and a boundary layer generate the coefficient of kinematic viscosity of delta and gas for the thickness of a boundary layer delta2 =nu (L/V) (1) ** -- it is expressed. Change of thickness delta of a boundary layer will change a concentration gradient.

[0014] in order to prevent this L/V= -- fixed (2) ****** -- it is possible to make delta regularity, i.e., a concentration gradient, not change. The cross-section configuration of a flow channel where gas flows can determine uniquely change of the rate of flow V of the gas in a flow direction. If the cross section is set to S, since it is fixed, the total flow F of gas is the product of V and S. F=V-S = fixed (3) It becomes. This is solved about V and it is a formula (2). If it substitutes L/V=(L-S)/F (4) It becomes and fixed, then delta can be made regularity for the product of L and S.

[0015] The upper edge L which a boundary layer generates here is an upper edge where gas begins to serve as a laminar flow, and this must take into consideration a configuration with detailed gas exit cone and flow channel etc. by computer simulation etc. in accuracy, and it must calculate it according to hydrodynamics. However, usually it is growing up on the conditions which serve as a laminar flow from

the exit cone of gas with a great portion of vapor growth equipment, and surely serve as a laminar flow within a flow channel even when that is not right. Therefore, gas may also consider the exit cone of gas, or the upper edge of a flow channel to be the upper edge which begins to serve as a laminar flow.
[0016] Growth of a thin film with a uniform growth rate is attained in a flow direction, without rotating a wafer, if it is made to change from the above thing in the flow direction of gas as a function of the distance from the exit cone of the gas which is the upper edge where a boundary layer generates the cross-sectional area of a flow channel, or the upper edge of a flow channel. Consequently, the thin film of atomic level called a number atomic layer can also be easily made into homogeneity in a wafer side, and it becomes easy [a superstructure etc.] to grow up [of a super-thin film] it.
[0017]
[Example] The example of the vapor growth equipment of this invention is explained below.
[0018] The cross section vertical to the flow of gas is carrying out the rectangle, and drawing 1 shows the horizontal-type flow channel 1 of the horizontal-type vapor growth equipment carried out as [extract / the cross-sectional area / in the flow direction of gas / gradually]. (a) is drawing of longitudinal section and (b) is an A-A' line sectional view.
[0019] Establish two or more holes for wafer 2 in the top face 5 of the flow channel 1 along a flow direction, the hole is made to face by making a wafer 2 a face down (it being facing down about a growth side), and it is made for the material gas in the flow channel 1 to flow to a wafer 2 and parallel. Material gas is exhausted from an exhaust port 4 through the gas exit cone 3 of the flow channel 1.
[0020] In order to set constant the product of the distance L from the exit cone 3 of gas, and the cross-sectional area S of the flow channel 1, the width of face W of the flow channel 1 presupposes that it is fixed, and makes the thickness h in inverse proportion to distance L. The thickness of the boundary layer formed in a wafer 2 by this can be kept constant to a flow direction.
[0021] Specifically, it was referred to as distance L0 =1,000mm from width of face of W= 300mm of the flow channel 1, and the gas exit cone 3 to an exhaust port 4, and h= 1.2x104 / Lmm. Moreover, in order to make thickness h in inverse proportion to distance L, it was made to carry out curved-surface processing of the base 6 of the flow channel 1 of a wafer 2 and an opposite hand.
[0022] Epitaxial growth of gallium arsenide was performed by metal-organic chemical vapor deposition using this equipment. As a raw material, the carrier gas with which trimethylgallium, an arsine, and a substrate convey gallium arsenide and a raw material performed pure hydrogen and growth temperature at 600-700 degrees C, arranged 3-5 wafers in the flow direction, and investigated change of the growth thickness in a flow direction.
[0023] Consequently, uniform film distribution as shown in drawing 2 was acquired between wafers and in the wafer side. The flow direction usually used shows collectively the typical thickness distribution at the time of using the flow channel which does not change thickness for a comparison. The conditions of growth are the same. An improvement distinct to this example is accepted.
[0024] Next, the example of circular horizontal-type vapor growth equipment with a disc-like growth furnace is explained. It is circular to drawing 3 and the horizontal-type flow channel 7 to which thickness was changed in the flow direction of gas is shown. (a) is a top view and (b) is a sectional view.

[0025] It is made for the material gas in the flow channel 1 to flow to a wafer 2 and parallel by establishing two or more holes for wafer 2 in a radial along a flow direction, making a wafer 2 a face down and making that hole face the top face 8 of this flow channel 1 it. Material gas is supplied from the center of the flow channel 7, and is exhausted through the gas exit cone 10 by the method of the outside of the direction of a path. 11 shows the flow of the gas.
[0026] In order to set constant the product of the distance L from the exit cone 10 of gas, and the cross-sectional area S of the flow channel 1, thickness h of the flow channel 7 is made in inverse proportion to the square of the distance L from the exit cone 10 of gas (L-S= abbreviation L, 2piLxh=h, and 2piL2 = fixed). The thickness of the boundary layer formed in a wafer 2 by this can be kept constant to a flow direction.
[0027] Specifically, it was referred to as the diameter of phi= 800mm of a disc-like growth furnace, and

h=6.3x105 / L2 mm. In order to make thickness h in inverse proportion to the square of distance L, it was made to carry out curved-surface processing of the base 9 of the flow channel 7 of a wafer 2 and an opposite hand also here.
[0028] Epitaxial growth of gallium arsenide was performed on the same conditions as the example mentioned above using this equipment, and change of the growth thickness in a flow direction was investigated. Consequently, uniform thickness distribution as shown in drawing 4 was acquired between wafers and in the wafer side. The flow direction usually used shows collectively the typical thickness distribution at the time of using the flow channel which does not change thickness for a comparison. The conditions of growth are the same. An improvement distinct to this example is accepted.
[0029] In addition, although each example mentioned above made the wafer the face down and carried it out, in this invention, there is no essential semantics up and down, and effectiveness with the same said of face up is acquired. Moreover, although this example explained the case where gallium arsenide was grown epitaxially, it can apply to all the ingredient systems in which vapor growth is possible, and can apply also to deposition of the thin film instead of epitaxial growth.
[0030] Furthermore, although the cross section of a flow channel was changed by changing the base configuration of the flow channel of a wafer and an opposite hand in this example, the result same as changing the top-face configuration by the side of a wafer, of course is obtained. Moreover, in this example, although curved-surface processing of the flow channel is carried out, in order to consider as the configuration which is easier to process it, it is good also as straight-line approximation processing, and the same effectiveness is acquired by it. Moreover, need to continue curved-surface processing or straight-line approximation, and it is not necessary to necessarily give it to the overall length of a flow channel, and intrinsically, only the part in which a wafer exists is important and processing should just be performed about the part.
[0031]
[Effect of the Invention] A thin film with uniform thickness can be grown up without according to this invention approach, rotating a wafer, since the thickness of a boundary layer was kept constant to the flow direction.
[0032] According to this invention equipment, the thickness of a boundary layer can be kept constant to a flow direction with the easy structure of making the cross section or thickness of a flow channel in inverse proportion to distance from the upper edge where gas begins to serve as a laminar flow, the exit cone of gas, or the upper edge of a flow channel.
[0033] According to this invention equipment, also in a disc-like growth furnace, the thickness of a boundary layer can be kept constant to a flow direction with the easy structure of making the thickness of a flow channel in inverse proportion to the square of distance.
[0034] According to this invention equipment, since curved-surface processing by straight-line approximation has been performed to the top face or base of a flow channel, the fabrication of a flow channel is easy.

[Translation done.]